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BUREAU OF MINES
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ALEX U. MILLER AND EDWARD THOMAS

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UNITED STATES DEPARTMENT OF THE INTERIOR - BUREAU OF MINES

HAZARD OF METHANE FROM WELL WATER IN SOME SECTIONS OF ILLINOIS[1]

By Alex U. Miller[2] and Edward Thomas[3]

In March 1937 the entire country was shocked by news of an explosion of gas in a New London (Tex.) schoolhouse, which resulted in the death of 280 pupils and 14 teachers. The Government investigators of this disaster believed that the cause was the ignition and explosion of a large volume of explosive natural gas-air mixture that had accumulated in a poorly ventilated space beneath the first floor of the main school building and that this accumulation was due to leakage from gas lines suspended underneath the floor to carry the gas supply to the school.[4]

For some years there has been a potential explosion hazard in school houses and other buildings that are supplied with water from deep wells in certain parts of Illinois. Notwithstanding the disaster at New London, Tex., and the fact that there had been gas ignitions at four water wells in different parts of the State, the explosion hazard in schools and other buildings was not fully recognized until a few months after the disaster in Texas, when an explosion occurred in the settling basin of the municipal water works of Clinton, Ill., and another in a pump house of the municipal water works in Normal, Ill.

The explosion in the settling tank of the municipal water works in Clinton, Ill., occurred on August 12, 1937, and did considerable damage to the settling tank, but fortunately no one was injured. At the time of this explosion repairs and alterations to the water plant were in progress, and 10 men were employed in the immediate vicinity of the settling tank. Two of these men were enlarging a hole in the concrete side with an air hammer for the installation of a larger discharge line. They observed a

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[1] The Bureau of Mines will welcome reprinting of this paper, provided the following footnote acknowledgment is used: "Reprinted from Bureau of Mines Information Circular 7033."
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[4] Parker, D. J., Jones, G. W., Hill, H. B., and Wade, G., Explosion in School Building at New London, Tex., March 18, 1937: Report of Investigations 3365, Bureau of Mines, 1937, 29 pp.

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blue flame in the settling tank through the hole they were enlarging and ran about 50 feet from the tank, warning other men who were nearby. According to these men and other spectators, there were two distinct shocks, approximately 15 seconds apart, after the initial "puff" that warned the men. The second explosion raised the entire concrete roof about 18 inches, and the third raised the roof about 36 inches and shattered a large section of it. The two manhole covers of the tank were in place all morning, and it is very likely that pure gas had accumulated under the arched roof of the settling tank and the mixture of air and gas near the drillers was ignited either by a friction spark made by the air hammer and concrete or by a match used to light a cigarette.

On October 18, 1937, an explosion occurred in a closed brick pump house of the municipal water works of Normal, Ill. When two men, who were collecting water samples in the pump house, lighted a blow torch (which was used to sterilize the sample containers) an explosion occurred; they were injured seriously, the wooden roof was demolished, and a hole 8 by 12 feet was made in one of the brick walls of the pump house. No provision had been made for adequate ventilation of the settling tank at Clinton or the pump house at Normal.

As a result of these explosions the authorities became somewhat alarmed, and information on methods of eliminating the explosion hazard of gas liberated from the water was requested from State departments, including the Departments of Mines and Minerals, Public Health, Registration and Education, and the Illinois Water Survey, as well as the Safety Division of the Federal Bureau of Mines.

While investigating the explosion hazard, State and federal investigators collected samples of gases liberated from the water in some of the wells. Analyses of these samples showed a high percentage of the explosive gas, methane (CH_4), the gas that has been responsible for scores of coal-mine explosions with heavy death toll.

It is generally known that Illinois and other Middle Western States are covered with nearly parallel and approximately level strata of the Carboniferous age; when these strata are pierced by drill holes, the coal and shale strata liberate methane to some extent. In general, these strata slope slightly to the west and are covered by a fairly even sheet of glacial deposits, the southern extremity being in a line southwesterly through White, Gallatin, Saline, and Williamson Counties and thence northwestward to a point just south of St. Louis.

Geologists disagree as to whether all of this material was deposited during one glacial era or whether it is the product of successive glacial encroachments, but all agree that there were frequent oscillations of the glacial front to the extent that vegetation flourished between the periods of invasion. Peat beds were formed in the depression or were collected in the basins of the dams, which were created by the moraines and glacial terraces, after the retreat of the glacier. The glacier covered the peat beds with deposits of sand, gravel, and clay when it invaded the territory the next time, with the result that the drift is stratified to a large extent and irregular lenslike deposits of peat and driftwood in varying stages of decomposition are scattered throughout the drift adjacent to water-bearing sands and gravel and sealed by impervious layers of clay. The existence of this stratification is borne out by borehole records throughout the glacial drift area of the State. Holes drilled into the gravel beds of the drift produce water in abundance.

Methane (CH_4), an important and frequently present product of decomposition of vegetable matter, is sealed under pressure by the overlying drift in contact with the water in the adjacent sand and gravel beds, and consequently quantities of the gas are in solution in the water. At standard conditions of temperature and pressure (0° C. and 760 mm Hg), the solubility of methane is 5.45 cc in 100 cc of water.

Methane is colorless, odorless, tasteless, flammable, and nonpoisonous. Its specific gravity at 760 mm (sea level) and 0° C. (32°F.) is 0.5545. Air that contains 5 to 15 percent by volume of methane is explosive, the most explosive point being when the air contains about 10 percent methane. The ignition temperature is between 999° and 1,452° F.

There are several methods of detecting the presence of methane in a building or other enclosed space. In coal mines, where more or less methane is encountered, the flame safety lamp is used to a large extent to determine its presence. The modern permissible safety lamp encloses a naphtha flame within a glass chimney and two truncated, cone-shaped, fine-mesh, wire gages that sit on the chimney. Concentrations of methane from 1 to 5 percent can be detected with a flame safety lamp by estimating the length of the "gas cap" on the flame or by the elongation of the flame; quantities greater than 5 percent either explode or burn within the lamp.

A number of available mechanical devices are more accurate and more nearly safe than the flame safety lamp for detecting methane, particularly in small percentages. These devices operate on the principle that the electrical resistance of a heated filament increases when its temperature is raised by conducting a combustible gas over it. The change in resistance is measured by a galvanometer placed across a Wheatstone-bridge circuit. The dial is calibrated to indicate concentrations as low as 0.01 percent. Continuous methane recorders that operate on this principle also are available. The percentage of methane may be determined also from air samples by the Orsat or Haldane apparatus.

In 1933, State engineers made a survey of ground waters, in which approximately one-third of the State was covered. These men were not instructed to report the presence of gas and probably did so only when the amount given off from the water was particularly noticeable. According to the survey, gas was reported in 23 counties of the State; the extreme southern county surveyed was Washington, the western, Henderson, the northern, Lake, and the eastern, Edgar. It was reported that the gas had

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ignited at water wells in Macon, Dewitt, and Lake Counties, T. E. Larson, chemist of the Illinois Water Survey, makes the following statement regarding the survey of the ground waters of Illinois:

> Although the territories covered are not limited to a few sections of the State, the fact that two-thirds of the total area was not covered indicates that many zones or portions have not been reported. Several of the zones reported are composed of but one well in that locality in which the presence of gas was noted, but it would be safe to say the other wells in the vicinity may or will be of the same nature. From the data at hand, most of the counties north of a line across the State from Clark County on the east to Calhoun County on the west, could be expected to find gas in well waters penetrating hardpan into sand or quicksand, or wells obtaining water from or penetrating old river bottoms.

The information obtained by the survey of ground waters in Illinois, together with the fact that two explosions have occurred relatively recently at municipal water works and four gas ignitions at water wells, indicates beyond a reasonable doubt that every precaution should be taken at schools, municipal water works, industrial plants, and homes supplied with water from deep wells that contain explosive gas, and all deep wells in this region should be considered potential sources of explosive gas. If the waters from deep wells in basements of schools or industrial plants contain explosive gas, it would be possible for an explosive mixture of gas and air to accumulate in the basement and, if ignited, cause such a disaster as occurred at New London, Tex.

To prevent the explosion of an explosive gas liberated from deep well water, the following suggestions or recommendations are offered:

1. Samples of gases given off by the water should be collected and analyzed for explosive gas by a competent chemist or gas analyst.

2. If explosive gas is being liberated, it should be removed from the water by aeration before the water is used. This should be done immediately after the water leaves the pump and before it enters an enclosed reservoir or treating plant.

Aerating can be done by means of sprays, baffle plates, aeration coke trays, or any other practical device that permits the finely divided water to come in contact with fresh air. The choice of method will depend largely on the results of an analysis of the water to determine whether there are any other objectionable impurities that may be treated or removed simultaneously with the methane.

3. The wells and aeration units should be far enough from buildings to prevent entrance into them of any gas given off during the aeration process.

4. Buildings housing pumps that handle unaerated water should be used as pump houses only and should not have basements or passageways to other buildings wherein gas might accumulate. Ventilation should be adequate. All wires should be enclosed in gas-tight conduits. Electric switches and motors used for driving pumps or other equipment should be of the permissible type,[5] or those approved by the National Board of Fire Underwriters. Properly maintained permissible electrical equipment will not ignite explosive gas and air mixtures. Smoking should not be permitted in or around pump houses, aeration units, or settling tanks.

5. Buildings in which gas could accumulate should be built with as little dead-air space as possible, especially in basements, between foundations, etc. Gas lines, meters, and gas appliances should be installed in accordance with American Gas Association requirements for house-piping and appliance installation.[6]

The writers express their appreciation to James McSherry, director, State Department of Mines and Minerals, Springfield, Ill.; T. E. Larson, chief chemist, Illinois Water Survey, and G. H. Cady, senior geologist, State Geological Survey, Urbana, Ill.; and to other State employees who assisted in obtaining the information contained in this paper.

5/ A list of electrical equipment approved as permissible by the Bureau of Mines may be obtained by writing to the Director, Bureau of Mines, United States Department of the Interior, Washington, D. C.

6/ For more detailed recommendations regarding design of public buildings, see Bureau of Mines Report of Investigations 3365, referred to in footnote 4.